PATENT SPECIFICATION

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(21) Application No. 34136/76 (22) Filed 17 Aug. 1976
(31) Convention Application No. 620086
(32) Filed 6 Oct 1975 in
(33) United States of America (US)
(44) Complete Specification published 1 March 1978
(51) INT CL[2] F21V 9/04//7/05 7/06 7/07 7/08 7/12 7/22 13/08
(52) Index at acceptance
F4R 337 392 39Y 410 41Y 547 614 617 618 619 621 627 62Y 631 632 633 634 635 636 641 649

(19) THE PATENT OFFICE LONDON

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(54) ILLUMINATION SYSTEM INCORPORATING AN INFRA-RED FILTER

(71) We, INTERNATIONAL BUSINESS MACHINES CORPORATION, a Corporation organized and existing under the laws of the State of New York in the United States of America, of Armonk, New York 10504, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the field of illumination systems incorporating infra-red filters.

Numerous geometric configurations of reflectors and filters employing various shape conic sections have been designed into illumination systems for reflecting and filtering light rays. Generally, in illumination systems used, for example, in xerographic reproducing apparatus, or other electrophotographic systems, it is desired to focus the visible spectrum produced by a light source onto a document scan station after filtering out the infra-red (IR) spectrum and directing those rays to a heat sink. In these prior art systems so-called hot mirrors are widely used and are effective for transmitting the visible spectrum while reflecting the infra-red rays. Cold mirrors which transmit IR while reflecting the visible spectrum are also used, and are preferable to hot mirrors since they usually produce a more efficient heat/light separation. However, both cold and hot mirror systems as known in the prior art have been designed to take the separated infra-red spectrum and direct it to a heat sink, and therefore that portion of the energy consumed by the light source going into the production of IR is wasted.

According to the invention there is provided an illumination system comprising an incandescent light source and a reflector arranged to generate an illuminating light beam and a filter device positioned to intercept the beam and to reflect infra-red components thereof back to the light source for focussing thereon.

In order that the invention can be fully understood, preferred embodiments thereof, will now be described with reference to the accompanying drawings, in which:

Figure 1 shows an illumination system in which the visible spectrum is directly passed through a plane hot mirror while the infra-red spectrum is folded back upon the light source;

Figures 2 and 3 show the angles of radiation in which rays are reflected upon the light source;

Figure 4 shows a variation on the structure of Figure 1;

Figure 5 shows a second embodiment of the illumination system wherein a hyperbolic hot mirror is employed;

Figure 6 shows another embodiment of the invention in which a cold mirror is employed with a hyperbolic reflector for reflecting the infra-red spectrum back to the light source;

Figure 7 is still another embodiment of the invention utilizing a cold mirror and a plane reflector;

Figure 8 shows a hot mirror embodiment with parabolic reflectors;

Figure 9 is a variation on Figure 8 using a cold mirror scheme; and

Figure 10 shows an overall diagrammatic view of light reflection in a typical electrophotographic machine.

Figure 1 shows an embodiment of the invention for use in electrophotographic apparatus wherein an incandescent lamp 10, which may be of the tungsten-halogen type, is placed at the focal point of a reflector 11. Reflector 11 can be shaped in the form of any suitable conic section, an elliptical form being illustrated in Figure 1. While not shown in Figure 1, both lamp 10 and reflector 11 are preferably cylindrical in shape in order to produce a line of light

to scan a document to be copied; therefore, reflector 11 is an elliptical cylinder and lamp 10 is a cylindrical bulb located along the focal line of the elliptical reflector 11. The major and minor axes of the ellipse are shown at 14 and 15 respectively.

In operation in an electrophotographic copier, the visible spectrum produced by light source 10 is directed on the document glass 12 through the plane heat reflecting interference filter (hot mirror) 13, which also acts to reflect infra-red (IR) radiation back upon the incandescent lamp 10. Note that the plane filter 13 must be located along the minor axis 15 in order to reflect the IR rays to the lamp.

To illustrate the operation of the illumination system shown in Figure 1, light rays 16 and 17 are shown emanating from incandescent lamp 10 and striking the elliptical cylinder reflector 11. From the reflector surface, ray 16 is directed toward filter 13, at which point the visible spectrum continues through the filter, as shown at 16′ to the document glass. Similarly, ray 17 is directed from the elliptical reflector through filter 13 to a focal point on the document glass as shown at 17′. At the same time, the infra-red radiation at 16″ and 17″ is folded back from the hot mirror 13 upon the incandescent lamp 10.

As a result of the arrangement shown in Figure 1, the hot mirror directs the IR back on to the source while the visible light passes through the hot mirror and is used to illuminate the document. Since the IR is directed on to the filament, it aids in heating the filament. This, in effect, allows a reduction of the electrical power required to heat the filament to the same temperature, or allows a higher temperature to be reached by the filament for the same electrical power.

Figures 2 and 3 show that in the arrangement of Figure 1 not all of the IR produced by the lamp source is reflected back upon the filament. Those rays emanating throughout the angles θ_1 in Figure 2 and the angle θ_2 in Figure 3 are reflected by the illumination system back upon the filament, while those rays which emanate from the light source and pass between the edges 18 and 18′ of the elliptical cylinder and the edges 19 and 19′ of the hot mirror are lost to the system. Consequently, in order to collect a full 360 degrees of IR radiation, it is necessary to extend the edges 18 and 18′ of the elliptical cylinder until the ellipse forms a full half-section, in which case edges 18 and 19 join so that the plane hot mirror can be located against the elliptical cylinder as shown in Figure 4. Such an arrangement has the further advantage in that it eliminates any angular and spacing adjustment between the filter and the reflector.

In order to reduce the size of the illumination system, another embodiment is shown in Figure 5, wherein the plane hot mirror of Figure 1 is replaced by a hyperbolic cylindrical hot mirror 20. By locating the foci of the hyperbolic hot mirror 20 at the foci of the elliptical reflector 11, a full 360 degrees of IR is collected and focussed back onto the filament 10. Also, since the hot mirror can be mounted against the elliptical cylinder, all adjustments between the two are eliminated. The illumination system of Figure 5 is physically smaller than those of Figures 1 and 4 because the elliptical cylinder 11 is less than a full half-section.

It may be noted in Figure 5 that any IR ray contained within θ_1 will strike the ellipse, then the hyperbola, and then be redirected to its source. Any IR ray contained within θ_2 will strike the hyperbola, then the ellipse, and finally be redirected to its source. The visible light within θ_1 passes through the hot mirror and is focused at the document plane.

As mentioned above, cold mirrors are a more efficient filter than hot mirrors. Consequently, the illumination system shown in Figure 6 has been designed to operate according to the principles of the invention while utilizing a cold mirror. In Figure 6 the visible light rays are shown emanating from lamp 10, striking the elliptical reflector 11, being directed to the plane cold mirror 21 and from there folded into focus at the document plane 12. The IR portion of these rays passes directly through the cold mirror 21 to a hyperbolic reflector 22 and from there is reflected back upon the light source 10. The hyperbolic reflector 22 must be aligned such that its foci are coincident with the foci of the elliptical reflector 11. Note that the cold mirror 21 crosses the minor axis 15.

Figure 7 shows another embodiment of the system for the case where the cold mirror 21 does not cross the minor axis of the elliptical reflector 11. In this case the plane reflector 23 is shown in position along the minor axis 14 in order to collect the infra-red radiation passing through cold mirror 21 and reflecting these rays back upon the incandescent lamp source 10.

While Figures 6 and 7 have the advantage of utilizing cold mirrors, they have the disadvantage over the embodiment shown in Figures 4 and 5 of losing that portion of the infra-red radiation which does not strike the hyperbolic reflector 22 or the plane reflector 23.

Figure 8 shows an embodiment wherein a point light source, lamp 10, is located at the center of a spherical concentrator 24 and at

the focal point of a paraboloid reflector 11. Both concentrator 24 and reflector 11 are made from aluminum and are polished for high reflectivity. Paraboloid 11 produces a column of light as shown in Figure 8 which is directed toward scan mirror 25 which is shaped as a parabolic cylinder in order to focus the light at document plane 12. A hot mirror 13 may be inserted at any point in the optical path between reflector 11 and scan mirror 25 in order to separate the IR and focus it back onto the lamp 10. Note that when a hot mirror 13 is not used, parabolic scan mirror 25 would be a cold mirror instead of an ordinary polished aluminum reflector in order to separate the IR; therefore, the use of hot mirror 13 provides a factor of ease in manufacturability over prior art arrangements. Note also that a cylindrical lamp 10 instead of a point light source and a reflector 11 shaped as a parabolic cylinder instead of a paraboloid could be used in Figure 8. However, use of hot mirror 13 would still provide the same significant manufacturing advantage by eliminating the need for a cold mirror at 25.

Figure 9 is a variation on Figure 8 utilizing a cold mirror reflecting scheme. Lamp 10 is once again located at the center of a spherical concentrator 24 and at the focal point of a paraboloid reflector 11. A collimated light beam is produced and directed toward plane cold mirror 21 from whence the visible spectrum is redirected to the parabolic cylindrical scan mirror 25 for focusing onto the document plane 12. Meanwhile, the IR is passed through cold mirror 21 to a plane aluminum reflector 23 from whence it is reversed directly back through mirror 21 to reflector 11 for focusing onto lamp 10.

The illumination systems described herein are of particular value to electrophotographic apparatus utilizing tungsten-halogen lamps where there is a frequent on-off operation of the lamp during the copying cycle. Depending on the length of off time, the tungsten-halogen lamp may cool below the temperature necessary for the halogen cycle. Through use of the optical system described herein, the temperature of the bulb wall is brought above the minimum required temperature at a quicker rate and kept there for a longer portion of both the on and off time than would otherwise be possible with the result that the illumination intensity of the bulb decreases at a reduced rate with hours of use.

Figure 10 sets the invention into the perspective of various other components in an existing electrophotographic machine such as the IBM Copier II. The illumination system comprising light source, reflectors and filters described in the embodiments above is shown at 30 and the document glass is shown at 12. Figure 10 shows that instead of directing the visible spectrum directly upon the document glass, it structurally may be more convenient to fold the visible spectrum at mirror 31 which then reflects a collimated line of the light upon the document glass 12. Figure 10 shows the use eventually to be made of the visible spectrum in that the scan of the document glass is shown reflected through a system of mirrors 32—35 to the drum 36 for image reproduction.

WHAT WE CLAIM IS:—

1. An illumination system comprising an incandescent light source and a reflector arranged to generate an illuminating light beam and a filter device positioned to intercept the beam and to reflect infra-red components thereof back to the light source for focussing thereon.

2. A system as claimed in claim 1 in which the filter device is a planar hot mirror.

3. An illumination system as claimed in claim 1 in which the filter device is a hyperbolic hot mirror.

4. An illumination system as claimed in any of claims 1 to 3 in which the light source is of tubular form, the reflector is of elongated form with an eliptical cross section and the filter device is positioned to enclose the open, light emitting side of the reflector.

5. An illumination system as claimed in claim 1 in which the filter device includes a plane cold mirror positioned to reflect the beam through a predetermined angle and to pass said infra-red components unreflected, and a further reflector positioned to reflect the infra-red components, after passage through the cold mirror, back towards the light source.

6. An illumination system as claimed in claim 5 in which the further reflector is planar.

7. An illumination system as claimed in claim 5 in which the further reflector presents a convex surface to said components.

8. An illumination system substantially as described herein with reference to Figures 1 to 3 of the accompanying drawings.

9. An illuminating system substantially as described herein with reference to Figure 4 of the accompanying drawings.

10. An illuminating system substantially as described herein with reference to Figure 5 of the accompanying drawings.

11. An illuminating system substantially as described herein with reference to Figure 6 of the accompanying drawings.

12. An illuminating system substantially

as described herein with reference to Figure 7 of the accompanying drawings.

13. An illuminating system substantially as described herein with reference to Figure 8 of the accompanying drawings.

14. An illuminating system substantially as described herein with reference to Figure 9 of the accompanying drawings.

15. An illuminating system substantially as described herein with reference to Figure 10 of the accompanying drawings.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1978
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

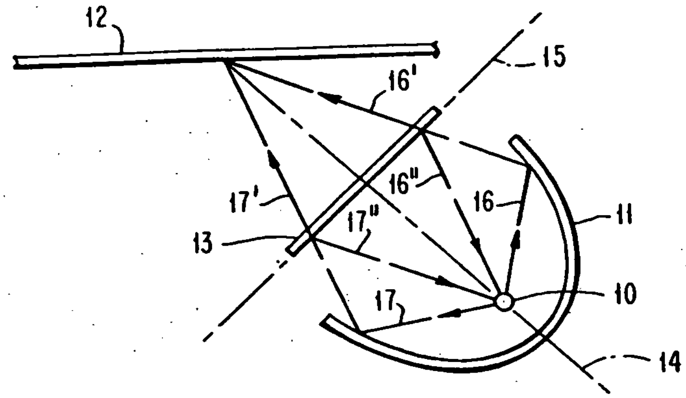

FIG. 1

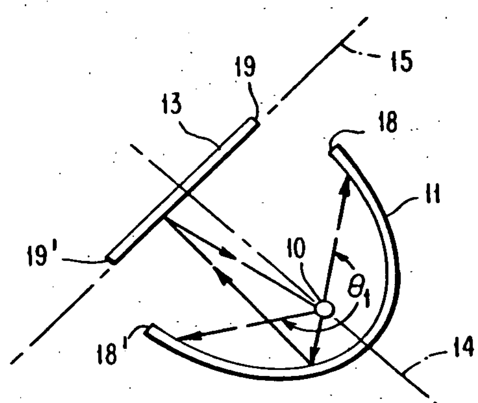

FIG. 2

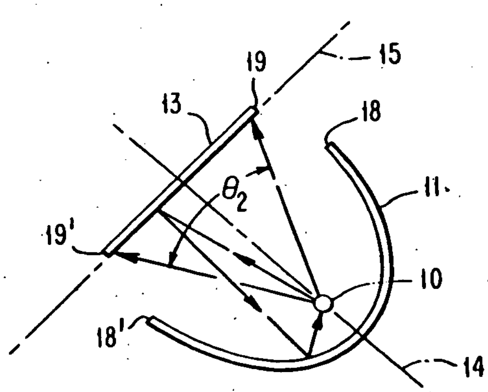

FIG. 3

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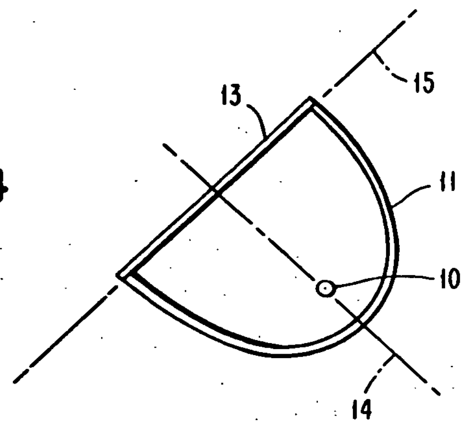
FIG. 4



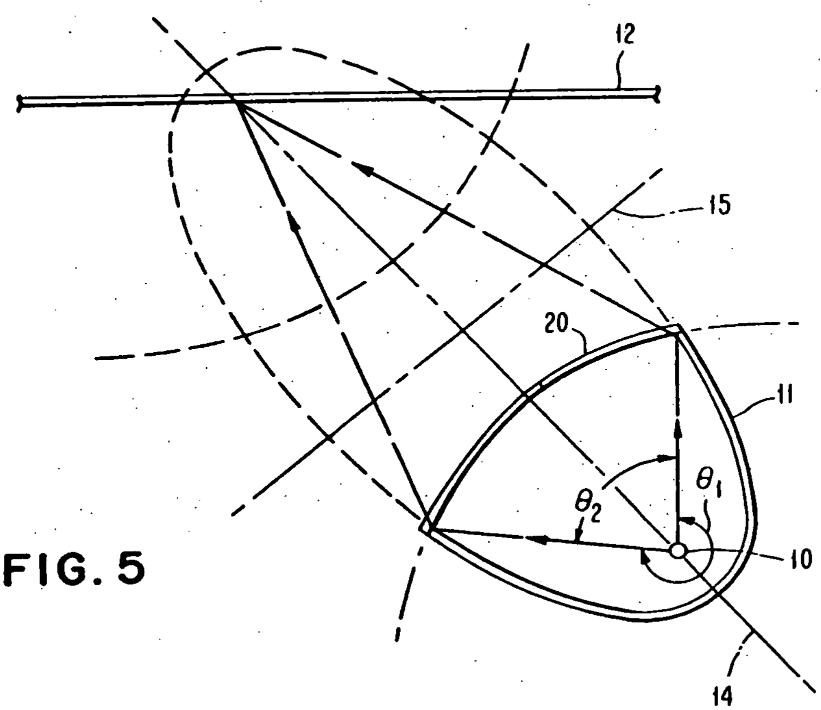


FIG. 5

FIG. 6

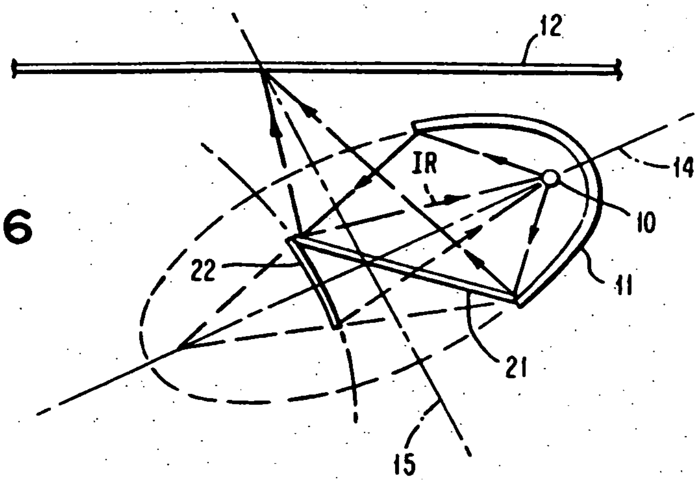
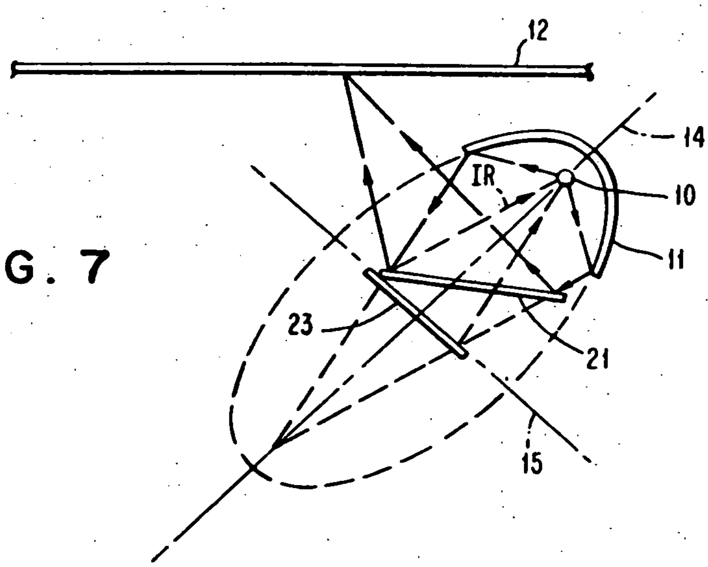


FIG. 7



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Sheet 4

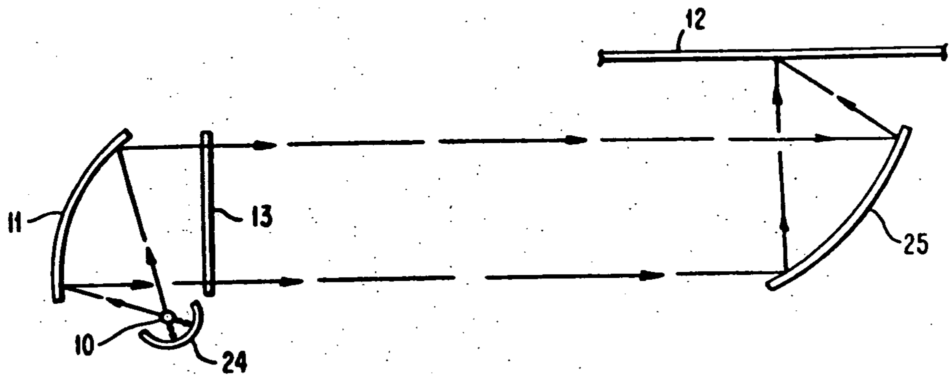

FIG. 8

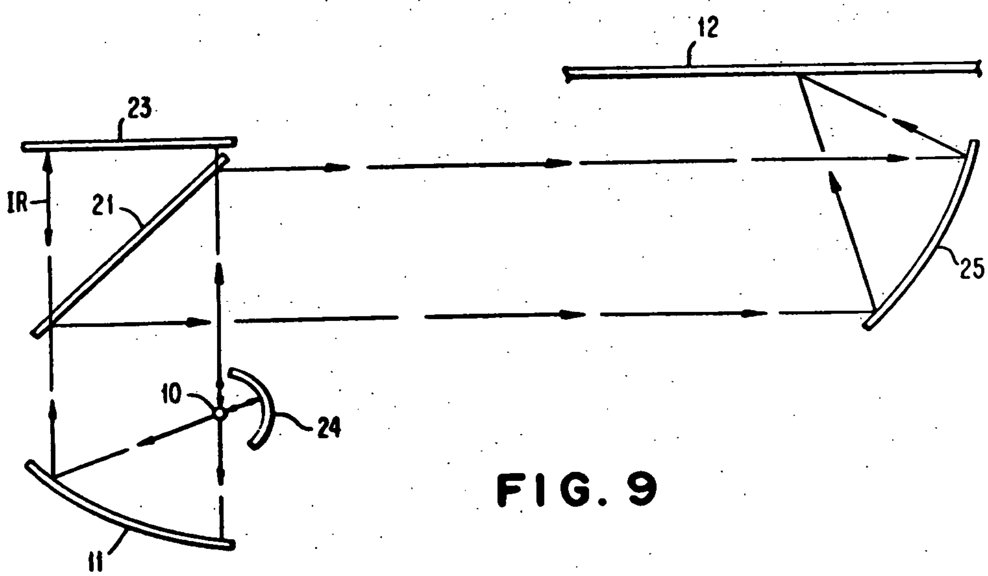

FIG. 9

1502729 COMPLETE SPECIFICATION

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Sheet 5

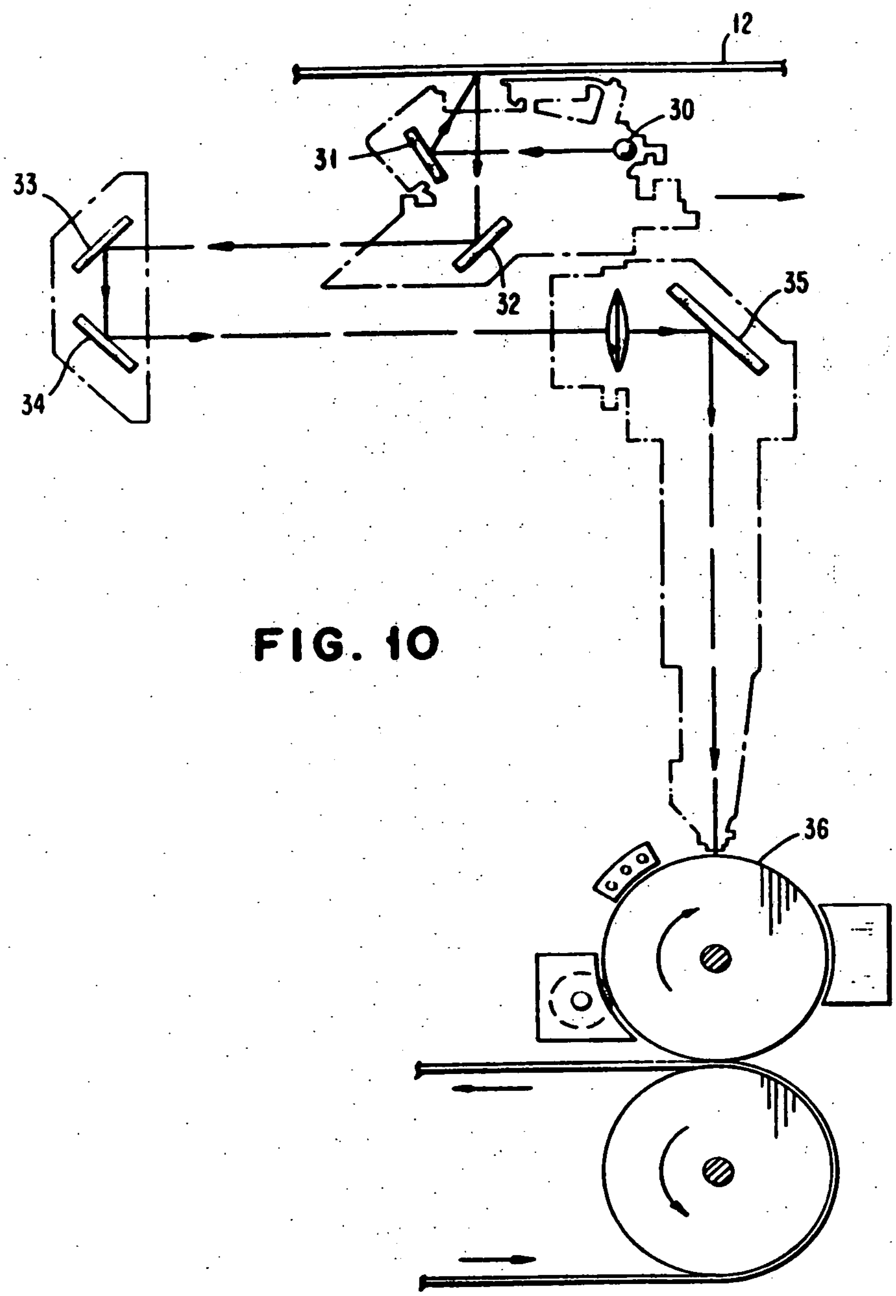

FIG. 10